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"Meteorological Utility of High Resolution Multispectral Data"

Contract # NAS 5-21741

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Washington, D.C.

(E73-10085) METEOROLOGICAL UTILITY OF  
HIGH RESOLUTION MULTISPECTRAL DATA  
Progress Report, period ending 30 Jan.  
1973 (Radio Corp. of America) 15 p HC  
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Original photography may be purchased from  
EROS Data Center  
10th and Dakota Avenue  
Sioux Falls, SD 57198

Details of illustrations in  
this document may be better  
studied on microfiche.

## 1.0 INTRODUCTION

This investigation is directed towards determining the meteorological information content of ERTS MSS bulk data at  $0.6 - 0.7\mu$  as a function of resolution. To accomplish this the resolution of the MSS data is degraded incrementally to 0.5 nmi. Subsequent analysis of the processed photographs in conjunction with surface and upper air observations will then determine to what extent significant meteorological information has been lost in the degradation process.

## 2.0 CURRENT PROBLEMS

The only significant problem encountered during the performance of this investigation has been the inability to obtain microfilm catalogues for selection of suitable scenes for processing. Actually viewing the scenes before selection is needed to obtain the wide variety of meteorological phenomena necessary to the attainment of any rational conclusions in the investigation. The alternative of visits to the NASA Data Processing Facility (NDPF) at Goddard Space Flight Center (GSFC) to use the browse file is both time consuming and expensive. (See Section 3.2).

## 3.0 CONTRACT PERFORMANCE

### 3.1 Phase I: Data Analysis Preparation

During the period from contract authorization, May 15, 1972, to the receipt of the first ERTS data on Oct. 2, 1972, the first phase of the contract was completed. Preparation and calibration of the resolution reduction process was accomplished.

Several selected Gemeni photographs were processed as a simulation of the ERTS MSS data processing. In addition, arrangements were completed for the acquisition of daily meteorological data to be used in the selection and subsequent evaluation of ERTS data.

### 3.1.1 Preparation for ERTS Data Processing

The initial proposal suggested that the resolution reduction of the ERTS data could be accomplished photographically using "slip sheets" or opaque screens. However, since the proposal RCA-AED had acquired an RCA 70/8802 flying spot color scanner and a Super Nova computer for associated real time digital processing of data. This system offered more control and quantitative measures of transfer functions in the resolution reduction process. With the read aperture spot size at .003 inch diameter, and using the ERTS MSS 70 mm format, simulation of image plane scanning radiometers with IFOV's of .138 nmi, .276 nmi and .552 nmi. diameter could readily be accomplished.

#### 3.1.1.1 Equipment Description

The color scanner facility at AED consists of a rotary read drum on which input photographic transparencies are placed, a set of read apertures, an 9 bit A/D converter, a Data General Corp. Super Nova computer, a D/A converter, a set of output write apertures, and a rotary write drum on which positive or negative transparencies can be produced.

TABLE I FACILITY PARAMETERS

Read Spot Aperture Shape & Size	Circular 3 mil
Read Line Advance	1 mil
Write Spot Aperture Shape & Size	Square 3 mil
Read and Write Spot Rate	80 ips

#### 3.1.1.2 Resolution Reduction Process

Figure 1 shows a block diagram of the resolution reduction process. The analog output of the "read" detector was digitized to 9 bit accuracy at a 33 K samp/sec rate along the scan line. Perpendicular to the scan direction, the read aperture was advanced in .001 in increments; only every third line - i.e. just contiguous lines were processed in the computer. The other two lines were discarded. The read aperture MTF is shown in Figure 2.

Figure 1 also depicts the averaging algorithm used to achieve the

desired resolution reduction. The resulting IFOV's and the effective sampling rates (in the along scan direction) are also shown. The effective sampling rate in the direction perpendicular to the scan was  $2xf_0$ , where  $f_0$  is the aperture frequency.

#### 3.1.1.3 Output Interpolation

The MTF of the "write" aperture on the color scanner is also shown in Figure 2. With a zero order hold on the output, the initial frames of Gemeni photos which were processed with a 4 x 4 average exhibited "contour noise" produced by the size (.012") and shape of the output aperture. This made evaluation of the degraded photos difficult. An example of this effect in the 4 x 4 average process is shown in Fig 3.

To eliminate this variation of output aperture size with resolution and to keep the aperture size near the lower limit for the resolution of the human eye (.003 in.), an interpolation algorithm was used on the output data. This algorithm is shown in Fig 4 and produced a constant .003 in. output aperture for the 4 x 4 average process. Although the output MTF of the system was changed slightly from that with no interpolation the effect is negligably small. (See Figure 2).

#### 3.1.2 Simulation of ERTS Processing Using Gemeni Photographs

Two Gemeni photographs of cloud scenes were selected for the ERTS simulation. These two frames were used during the initial processing effort, and except for the "contour noise" problem which was corrected by the interpolation algorithm, they successfully demonstrated the validity of the process to be used on the ERTS data.

#### 3.1.3 Additional Meteorological Data

An order was placed with the National Meteorological Center for the daily delivery of standard meteorological charts through 31 Dec. 1972.

The following charts were received on a daily basis during the period  
19 August - 31 December.

Northern Hemisphere Surface Chart

NMC 500 MB Analysis (Northern Hemisphere)

NMC 850 MB Analysis (Northern Hemisphere)

NMC 500 Winds (Northern Hemisphere)

It was intended that significant ERTS frames would be selected using these charts and the monthly catalogue of ERTS data. This subsequently proved unfeasible. However, the data will also be used in supporting the meteorological analysis of the ERTS frames after processing.

### 3.2 Phase II - Preliminary Data Analysis

The preliminary analysis began with the receipt of the first ERTS data on 2 Oct. 1972. A Data Query Form was submitted on August 16 requesting frames with cloud cover  $>40\%$  and sun elevation  $>40^\circ$  from the MSS. From this listing of  $\approx 40$  frames received on August 29, four frames in each of three spectral bands ( $.5-.6\mu$ ,  $.6-.7\mu$ ,  $.8-1.1\mu$ ) were requested with a Data Request form on August 29. When the data was received on 2 Oct. it was obvious that this method of data acquisition could not be used to obtain meteorologically significant frames. Only two scenes were useable, and even these contained little of significance. It is necessary to actually view the frames to select scenes that contain specific meteorological phenomena and will give significant results. The two useable scenes were processed to demonstrate the proposed techniques. Figures 5, 6, 7 and 8 show the original, 14 nmi., 28 nmi., and .56 nmi. resolution pictures respectively for one of these scenes in the  $.5-.6\mu$  band. The process proved to be efficient and give satisfactory results.

### 3.2.1 Analytical Results

Although these particular frames did not contain a great deal of significant meteorological information, certain interesting results were obtained. The scene contained many small fair weather cumulous clouds with an overlying veil of cirrus clouds which thickened towards the bottom portion of the frame. In the upper right, the cumulous clouds formed in streets along the low level wind direction. The wind direction was evidenced by the existence of the cumulous clouds over the water, where they would not naturally form because of the reduced heating. After the scene had been degraded to 0.5 nmi resolution, the cloud streets were still visible, but many of the smaller cumulous cells had lost their character. Also, the layered nature of the cloudiness was much less apparent. The interesting cloud formation just along the coast in the left center portion of the frame could be determined to be a very low stratus or fog deck when viewed at the original ERTS resolution because of the lack of shadows around the upper-left edges of the cloud formation. However, in the 0.25 and 0.5 nmi frames, there was nothing to distinguish it from several areas of coalesced cumulous cells.

In general, for this particular frame, little meteorological information was lost as a result of the resolution degradation from 100 meters to 0.25 nmi. Significant degradation just began to occur at 0.5 nmi.

### 3.2.2 Selection of ERTS Data

The processing of these initial frames pointed out that the method of selecting ERTS frames to be processed was critical to obtaining significant results from this study. (See Section 3.2). It is necessary that the scene content be actually viewed before a rational selection is possible. Thus, the microfilm catalogues that had been requested are a necessary part of the investigation.

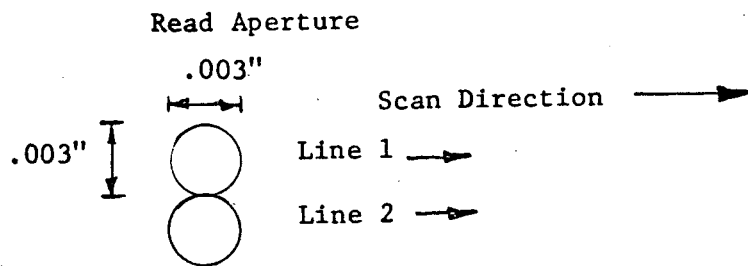
Also, with the launch of ITOS D (NOAA 2) on Oct. 15, 1972 into an orbit very similar to ERTS (790 nmi sun synchronous; 0900 descending node), it was felt that ERTS data should be obtained only after this date so that the data from the Very High Resolution Radiometer on NOAA 2 (0.5 nmi resolution, 0.5-0.7 $\mu$  and 10.5-12.5 $\mu$ ) that was taken simultaneously with the selected ERTS frames could be obtained and used to support the analysis of the degraded data. For this reason, requests for ERTS data were delayed until the catalogues for data taken after 15 Oct. 1972, were published.

Because microfilm catalogues were not being sent, the investigator of this study visited the browse file at NDPF, GSFC on Jan. 11, 1973 to select scenes for processing. The scenes selected were ordered on that date. Processing during Phase III will begin with the receipt of the pictures and the Data Analysis Plan approval.

#### 3.4 Data Analysis Plan

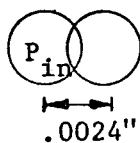
Based on the results of the initial processing of ERTS data (Phase II), a letter was sent to NASA on Jan. 7, 1973 as required, indicating that the basic analysis plan as described in the proposal would be followed and would produce significant results. Approval of this plan has not yet been received.

# I DIRECT IN/OUT



Sampling rate perpendicular to scan line =  $2 \times f_o$  where  $f_o$  is aperture frequency.

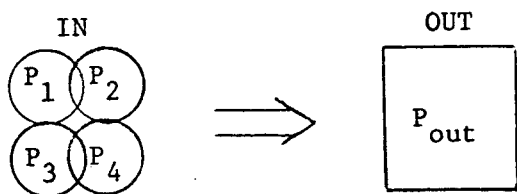
Digital samples taken every 2.4 mils along line ( $2.5 \times f_o$ )



Effective aperture  $\approx .003" \approx .176\text{mm}$ .

$$P_{in} = P_{out}$$

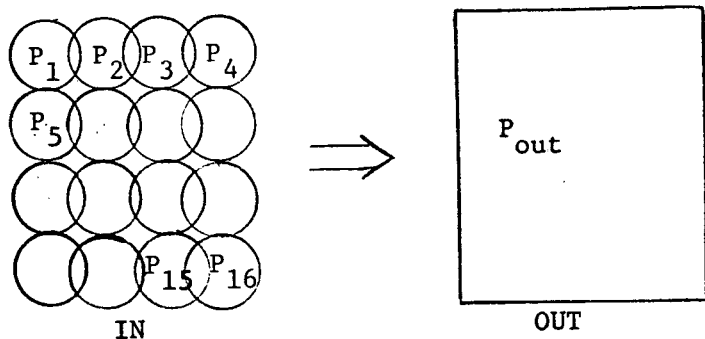
## II Average 2; shift 2 (both along and across scan)



Effective aperture  $\approx .006"$  square

$$P_{out} = P_1 + \frac{P_2 + P_3 + P_4}{4}$$

## III Average 4; shift 4 (both along and across scan)



Effective aperture  $\approx 0.12"$  square

$$P_{out} = P_1 + \frac{P_2 + \dots + P_{15} + P_{16}}{16}$$

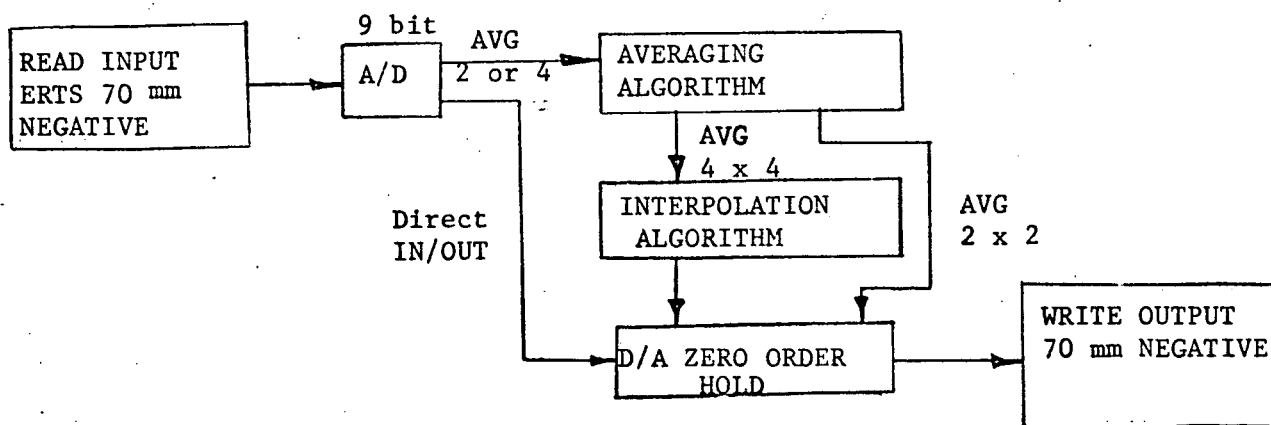
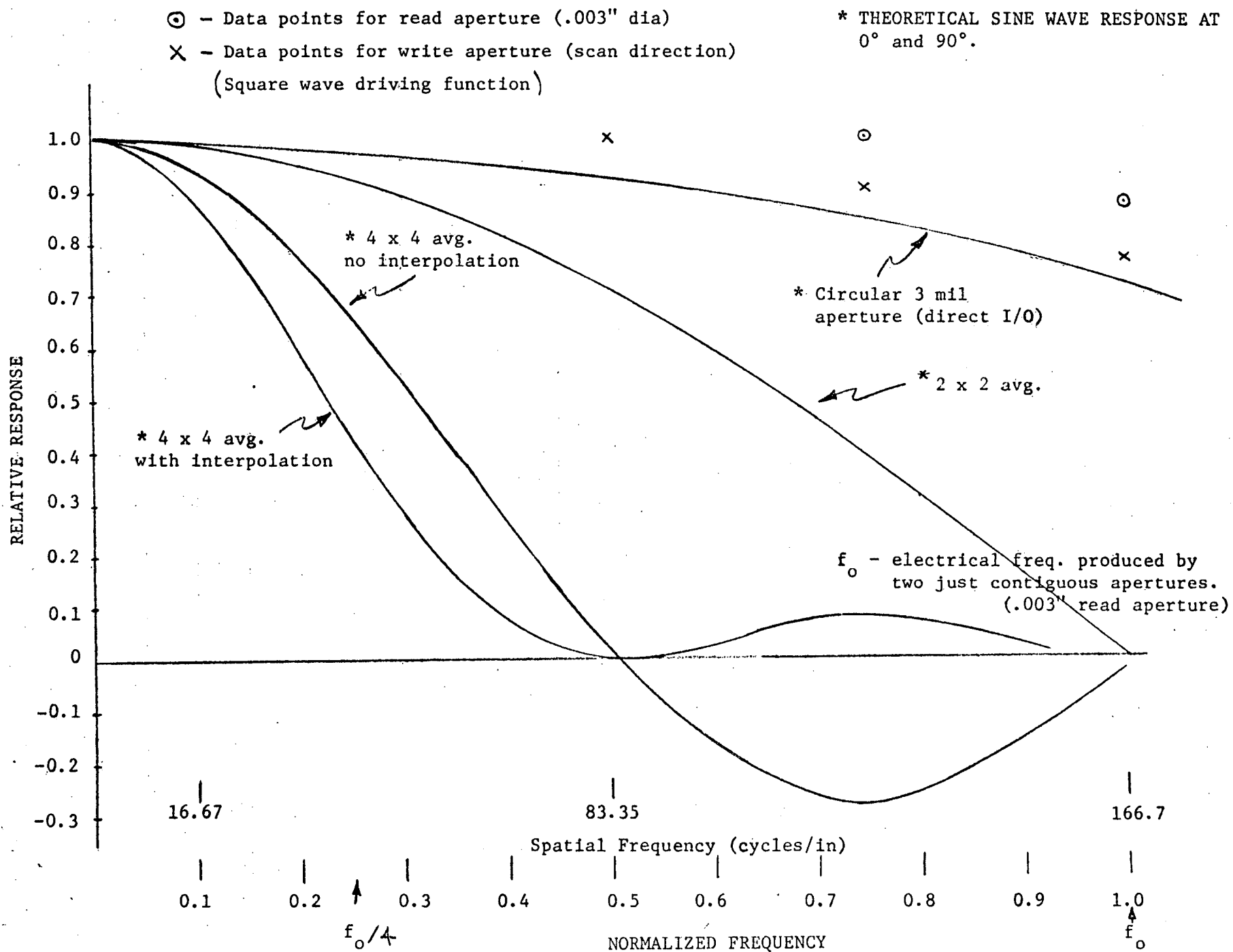
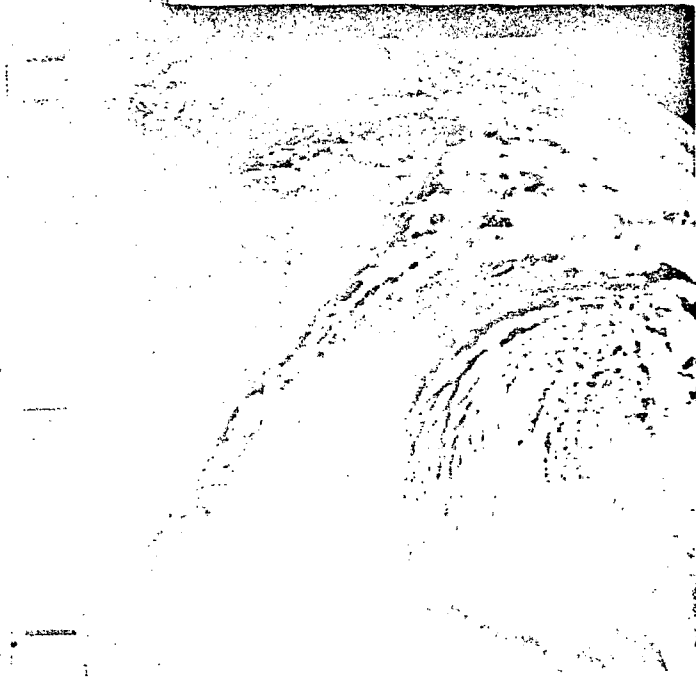


FIGURE 1 RESOLUTION REDUCTION PROCESS

FIGURE 2-PROCESSING MTF's





4 x 4 AVG  
NO INTERPOLATION

4 x 4 AVG  
WITH INTERPOLATION

FIGURE 3 OUTPUT  
INTERPOLATION

SCAN DIRECTION  
→

↑  
.003"  
↓

$P_1$	$P_1$	$P_1$	$P_1$	$P_2$
$P_1$	$P_1$	$P_1$	$P_1$	$P_2$
$P_1$	$P_1$	$P_1$	$P_1$	$P_2$
$P_1$	$P_1$	$P_1$	$P_1$	$P_2$
$P_3$	$P_3$	$P_3$	$P_3$	$P_4$

OUTPUT

NO INTERPOLATION

$P_1$	$X_{11}$	$X_{12}$	$X_{13}$	$P_2$
$O_{11}$	$O_{11}$	$O_{11}$	$O_{11}$	$O_{21}$
$O_{12}$	$O_{12}$	$O_{12}$	$O_{12}$	$O_{22}$
$O_{13}$	$O_{13}$	$O_{13}$	$O_{13}$	$O_{23}$
$P_3$	$X_{31}$	$X_{32}$	$X_{33}$	$P_4$

OUTPUT

AFTER INTERPOLATION

$P_m$  = Original pixel value after averaging

$X_{mn}$  = Pixel value after line interpolation

$O$  = Pixel value after row interpolation

↑  
.003"  
↓



= "read" pixel size

#### INTERPOLATION ALGORITHM - 4 x 4 AVERAGE

$$P_m = P_m$$

$$X_{m1} = 3/4 P_m + 1/4 P_{m+1}$$

$$X_{m2} = 1/2 P_m + 1/2 P_{m+1}$$

$$X_{m3} = 1/4 P_m + 3/4 P_{m+1}$$

$$O_{m1} = 3/4 P_m + 1/4 P_{m+1}$$

$$\text{or } 3/4 X_{mn} + 1/4 X_{m+1n}$$

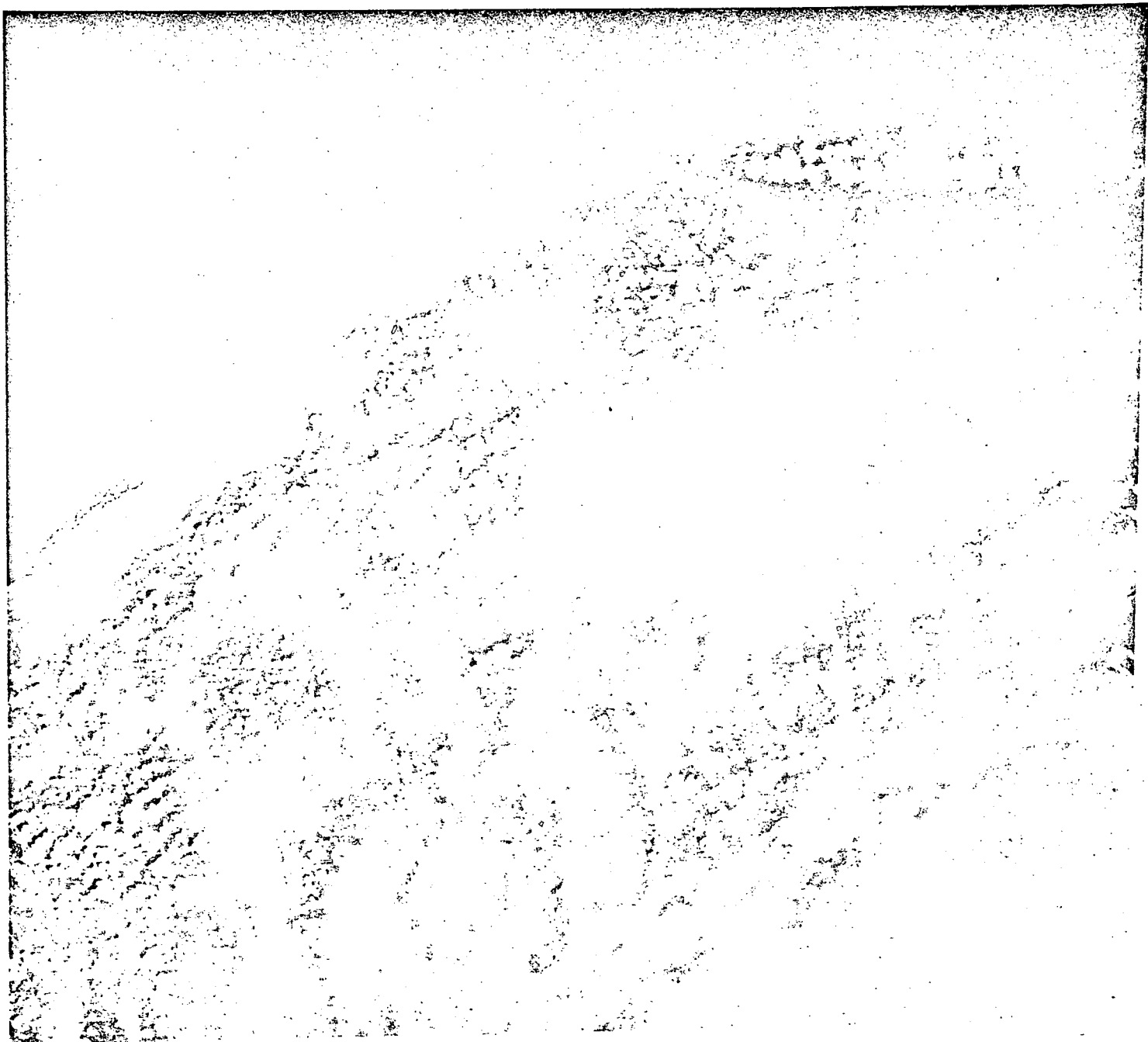
$$O_{m2} = 1/2 P_m + 1/2 X_{m+1m}$$

$$\text{or } 1/2 X_{mn} + 1/2 X_{m+1n}$$

$$O_{m3} = 1/4 P_m + 3/4 P_{m+1}$$

$$\text{or } 1/4 X_{mn} + 3/4 X_{m+1n}$$

FIGURE 4 INTERPOLATION PROCESS



26JUL72 C N48-51/W066-03 N N48-51/W066-01 MSS 5 D SUN EL54 AZ136 193-0040-N-1-A-D-L2 NASA ERTS E-1203-14482-5 02

FIGURE 5-ORIGINAL ERTS FRAME:RESOLUTION  $\approx$  100 METERS



FIGURE 6-DIRECT IN/OUT PROCESSED: RESOLUTION  $\approx 1/8$  nmi

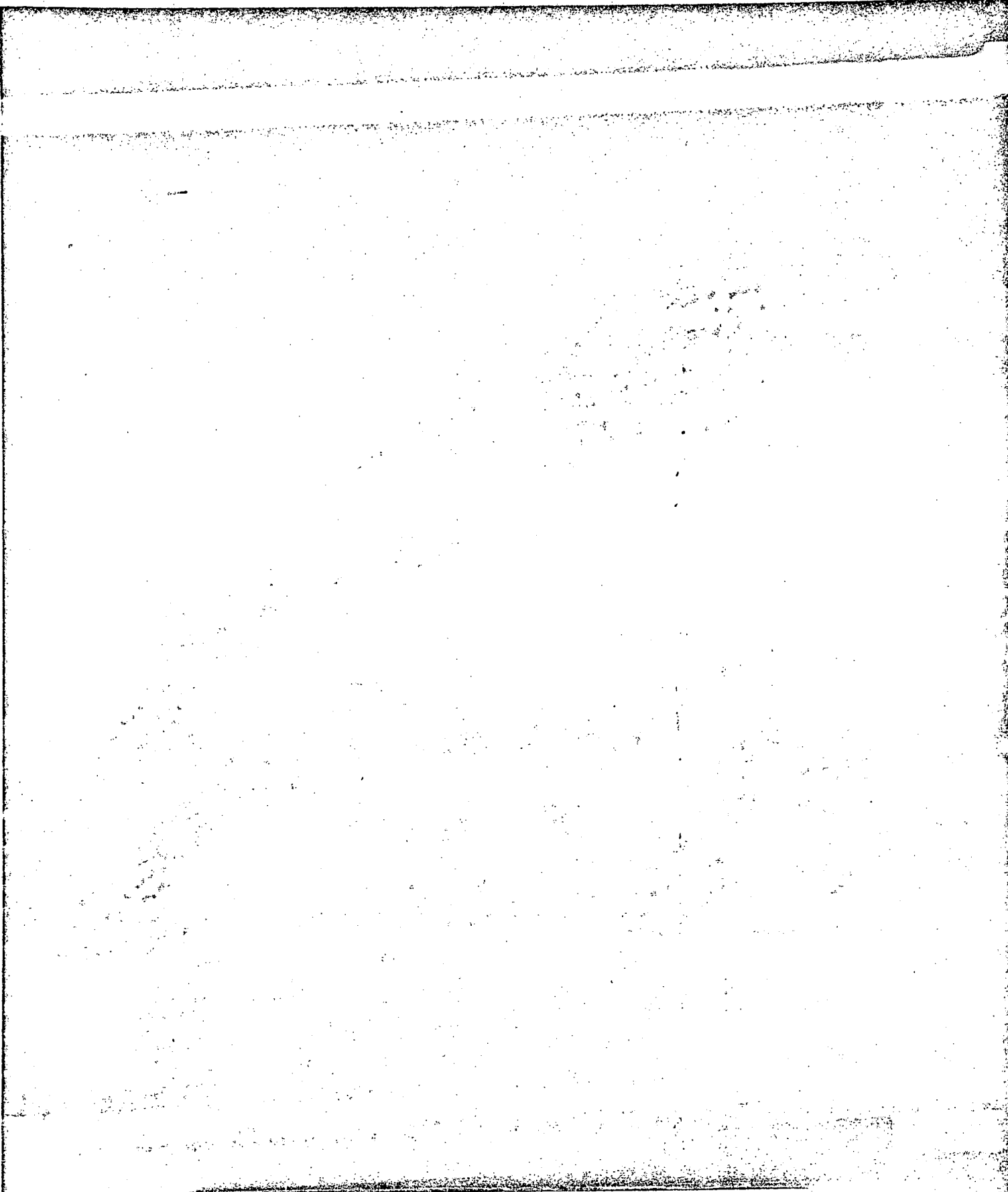


FIGURE 7-2  $\times 2$  AVERAGE PROCESSED: RESOLUTION  $\approx 1/4$  nmi

FIGURE 8-4 x 4 AVERAGE PROCESSED: RESOLUTION  $\sim 1/2$  nmi